REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT: 1972 Annual Report

Report No. 190800-2-F, December 1972

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN
Ann Arbor, Michigan

MICHIGAN STATE UNIVERSITY
East Lansing, Michigan

Prepared for
Office of University Affairs
National Aeronautics and Space Administration
Washington, D.C.

NOTICES

Sponsorship. The work reported herein was conducted by the Environmental Research Institute of Michigan for the National Aeronautics and Space Administration, Office of University Affairs, under Contract No. NSR 23-005-527. Mr. Joseph A. Vitale acted as Technical Monitor. Contracts and grants to the Institute for the support of sponsored research are administered through the Office of Contracts Administration.

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Infrared and Optics Division
Environmental Research Institute of Michigan

in cooperation with

Michigan State University

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FOREWORD

This project was performed for the Office of University Affairs, National Aeronautics and Space Administration by the Environmental Research Institute of Michigan (ERIM), with joint participation by Michigan State University (MSU) in the role of subcontractor. The Environmental Research Institute of Michigan is a non-profit corporation established on January 1, 1973 as successor to the Willow Run Laboratories of The University of Michigan. This report covers work performed from 1 September 1971 through 31 December 1972.

The goal of this project is to develop and apply earth resource survey technology to problems in land resource management of current concern to public agencies. The project undertook the acquisition and analysis of data over selected test areas in Southeast Michigan to demonstrate the use of remote sensing in the solution of current problems involving highway impact assessment and waterfowl habitat management. A more general goal of the project is to improve presently available methods of land inventory and evaluation as a contribution to the increasingly important government functions of land use planning and policy formulation.

This is one of several reports which will present the results of this project. The work is continuing under separate grants to the Environmental Research Institute and to Michigan State University, with joint effort being devoted to additional tasks on land resource management problems of current interest in the State of Michigan.

The investigations described herein were carried out under NASA Contract NSR 23-005-527. Joseph A. Vitale, Chief, Engineering Design Branch, Office of University Affairs, acted as Technical Monitor. The Project Director for this work was Richard R. Legault, Associate Director of ERIM, and the Principal Investigator was Irvin J. Sattinger, Research Engineer at ERIM. That portion of the technical program conducted by Michigan State University was performed under the direction of Myles G. Boylan, Director of the School of Urban Planning and Landscape Architecture, and Dr. Raymond D. Vlasin, Chairman of the Department of Resource Development.

ACKNOWLEDGMENTS

At ERIM, Thomas W. Wagner, Research Associate, was responsible for remote sensing analysis and interpretation in the M-14 Test Site study, with special emphasis on the application of multispectral scanner imagery. He was aided by Tim W. D. Gregg, Assistant in Research. A. N. Sellman, Research Associate, was responsible for ERIM activity in land use and land mapping studies, and for remote sensing analysis in the Pointe Mouillee study. He was aided by Robert D. Dillman, Research Assistant, and Laurence B. Istvan, Assistant in Research. Other ERIM staff members who contributed to these efforts include Fabian C. Polcyn, Research Engineer and Head, Technology Applications Group; Philip G. Hasell, Research Engineer, aircraft facility supervision; Leo A. Levereault, Research Associate, aircraft flight coordination; and Roland D. Kistler, Associate Research Engineer, multispectral scanner data processing.

At MSU, major contributions to this investigation were made as follows: Dr. Eugene P. Whiteside, Professor in the Department of Crop and Soil Science, Dr. Wayne Myers, Assistant Professor in the Department of Forestry, and Dr. Delbert Mokma, Research Associate in the Department of Crop and Soil Science were responsible for the investigations of soil and vegetation impacts. Dr. James Ahl, Research Associate, Stephen Schar, Research Specialist, and Mark Sullivan were responsible for the land use investigations. William Buckler and Mary Daup supervised and completed the cartographic tasks. The photographic interpretation and ground truth collection efforts necessary to the research were provided by William Enslin, George Cincala, Stanley Gorlitsky, and Kenneth Ottman under the supervision of John Fischer. Valuable assistance in data analysis and report writing was provided by Bryan Ernst, Linda Greenberg, Patricia Hagedon, Charlene Higgins and Mark Wilson.

For the Pointe Mouillee study, Mr. James Foote, Game Biologist for the Department of Natural Resources, provided invaluable assistance.

ABSTRACT

This project to demonstrate the application of earth resource survey technology to current problems within the State of Michigan was undertaken jointly by the Environmental Research Institute of Michigan and Michigan State University. Remote sensing techniques were employed to advantage in (1) providing management information for the Pointe Mouillee State Game Area, located at the mouth of the Huron River, and (2) preparing an impact assessment in advance of the projected construction of the M-14 freeway from Ann Arbor to Plymouth, Michigan. The project also assisted the state government in its current effort to develop and implement a statewide land management plan.

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1 SUMMARY

This project was undertaken jointly by the Environmental Research Institute of Michigan and Michigan State University to demonstrate the applicability of earth resource survey technology to current problems within the State of Michigan. More than 25 separate agencies at the federal, state, regional, and county levels were contacted in order to inventory the land and resource use problems currently facing such agencies. From the resulting discussions, a number of specific remote sensing applications were selected for detailed investigation.

In one of our investigations, now completed, we applied remote sensing methods in assessing the environmental impact of highway construction. Important factors and criteria to be considered in the assessment process were identified. Results indicated that remote sensing methods can be used to collect and present for analysis many types of data on land use, vegetation categories and species, soils in bare areas, and hydrologic characteristics. Among methods applied were analysis and presentation of pertinent information by means of overlay maps and computer processing of multispectral scanner data to provide automatic mapping of areas sensitive to damage. By using these methods to assess the environmental complications of the projected M-14 freeway from Ann Arbor to Plymouth, Michigan, we located several points along the route where damage may occur. Our work is being reviewed and evaluated by the State Highway Department's Environmental Liaison Unit for possible adoption in future impact assessment procedures.

Another investigative project begun during the year provided information needed for long-range planning as well as for day-to-day management of the Pointe Mouillee State Game Area, located at the mouth of the Huron River as it enters Lake Erie just south of Detroit. This is an important nesting area for waterfowl, a feeding and resting area on migration routes, and a duck hunting area. Both aerial photographs and multispectral scanner data were used to aid in assessing the extent of marsh delta deterioration brought about by wind and wave action.

Because the Department of Natural Resources is considering the acquisition of additional land to replace lost marsh habitat and to buffer the State Game Area against conflicting land uses, remote sensing data were also employed to evaluate lands adjacent to the present game area boundaries.

Aid was also provided toward the solution of a shorter-range management problem: that of improving the types and condition of vegetation necessary for wildlife food and cover. Vegetation inside a diked area—which is the only Pointe Mouillee tract actively managed to provide food and cover for waterfowl—was inventoried, classified by type, and mapped. This will enable the game manager to plan and implement needed improvements in habitat vegetation.

The project also assisted the state government in its current responsibility to develop and implement a state-wide land management plan. Providing direct consultation to the State Planning Division, the project staff made recommendations concerning efforts to standardize mapping and land use classification procedures. As a result of this effort, the State Planning Division provided separate funding to the Environmental Research Institute of Michigan for a short-range program of land use mapping to establish an initial record of the entire state's land use and natural resource distribution. This program will include operational use of ERTS-1 data for map updating.

2
INTRODUCTION

Manifold problems in resource use, covering a broad range of earth science disciplines and economic spheres, need to be addressed by public and private organizations. Accurate and reliable information is required so that short-range answers may be formulated. Long-range directions of public policy, particularly those that relate to the preservation of the quality and integrity of our land and water resources, also urgently demand attention.

A broad central purpose of this project is to demonstrate the part that earth resource survey science can play in solution of these problems.

Remote sensing equipment and techniques capable of collecting many types of data needed for intelligent analysis and decision-making have been developed in recent years. This information-gathering ability must now be exploited by developing operational uses and making remote sensing data available rapidly and economically to the ultimate user.

To move toward realization of such an operational capability, an interdisciplinary team was assembled to undertake the investigation of several problems of current interest to planning and operating agencies at federal, state and local levels in Michigan. With experience in earth resource disciplines as well as remote sensing technology reflected in team composition, the project was conducted jointly by staff members of the Environmental Research Institute of Michigan (ERIM) and by research and teaching faculty members of Michigan State University (MSU).

The scope and variety of problems faced by public and private agencies in Michigan are typical of those found in many other states. One of our investigations provided data useful in predicting the environmental impact of highway construction. Another supplied natural resource inventory data needed for the management of a state game area. A more fundamental project goal was to demonstrate and extend the applicability of remote sensing in formulation and implementation of public policies regarding land use throughout Michigan. Here, project timing was fortuitous since the State of Michigan is currently developing a policy for state-wide land use management and protection of its limited land resources. It was thus possible to make significant contributions at a very early stage of concept development and policy formulation.

Remote sensing applications can be effectively demonstrated only insofar as the necessary technology is widely accepted—by planning and operating agencies and eventually by private industry—as a means for problem solution. Accordingly, project personnel worked closely

with public agencies to stimulate their interest in this approach to problem-solving, advance their technical understanding of remote sensing applications, and thus possibly ensure favorable consideration of such applications in the future.

3
INVOLVEMENT OF USER AGENCIES

This section summarizes project experience gathered in the many initial and follow-up contacts with Michigan-based planning and operating agencies to explore and develop possible applications of earth resource survey techniques.

3.1. CONTACTS WITH USER AGENCIES

Table 1 lists those agencies at the federal, state, regional and county levels with which discussions have been held. This list is not exhaustive but includes those agencies with which contacts were more than nominal.

During the course of the first year, more than 100 meetings were held. One-fifth of these meetings were with county and regional planning units and one-fifth with federal agencies having offices in Michigan. One-half were held with state agencies and their component units, and the remainder were held with consultant groups and university-connected extension personnel.

Each of these Michigan-based agencies contributed to project research in at least one of three ways: by indicating key land and resource problems in Michigan for which the application of remote sensing holds promise; by providing needed information for the research efforts selected; by acting as client for the direct application of remote sensing to a real and manageable problem.

Both administrative and technical personnel at cooperating agencies were introduced to the potential uses of NASA-developed earth resource survey methods in attacking their current problems. Generally evoking a favorable response, the discussion sparked interest in further consideration of remote sensing applications. As the agency survey progressed, contact results were evaluated as well as the agency/contractor relationship. Providing useful guidance, these evaluations helped improve the second round of agency contacts now underway, and have shaped the type of research to be pursued under second-year efforts.

Cited here is one example of the interchange of information with agency staff: Project personnel worked closely with the Lake Central Regional Office of the Bureau of Outdoor Recreation, providing consultation on applications of remote sensing to problems of outdoor recreation planning. The Regional Office has purchased color infrared prints of the 1969 coverage of the Southeast Michigan region by the NASA RB-57 aircraft for recreation site analysis in connection with its studies of urban recreation sites, scenic trails, scenic rivers, and water-oriented rec-

TABLE 1. CONTACTS WITH GOVERNMENT AGENCIES

Federal Agencies in Michigan

Department of Agriculture
- Agricultural Stabilization and Conservation Service
- Economic Research Service
- Forest Service
- Soil Conservation Service

Department of Defense
- Army Corps of Engineers

Department of Interior
- Bureau of Outdoor Recreation

State Agencies

Department of Agriculture
Department of Commerce
Department of Natural Resources
Department of Public Health
Department of State Highways
Special Commission on Land Use
State Planning Division

Regional Agencies

Southeast Michigan Council of Governments
Tri-County Regional Planning Commission
Northwest Michigan Regional Planning Commission
Huron-Clinton Metropolitan Authority

County Agencies

Livingston County Planning Commission
Macomb County Planning Commission
Monroe County Regional Planning Commission
Oakland County Planning Commission
Washtenaw County Metropolitan Planning Commission
Wayne County Planning Commission

reation areas. The experience of Lake Central Regional Office personnel with this photography is described in a letter included as an Appendix to this report.

The Bureau of Outdoor Recreation has brought remote sensing technology to the attention of other government agencies with which it has contact. As a result, regional offices of the National Park Service and the Corps of Engineers have used RB-57 photography of the Indiana Dunes, Sleeping Bear Dunes and other sections of Michigan's western shoreline. Moreover, recreation planners have expressed interest in available RB-57 coverage of other states in the Lake Central Region and are also closely following the investigations of ERTS-1 imagery to determine its utility for recreation studies of regional scope.

The Detroit Metropolitan Airport has also purchased RB-57 photographs for use in its studies of airport expansion and its impact on surrounding communities.

Other opportunities were found to disseminate information on earth resource survey technology. Displays and accompanying lectures were brought to the attention of large numbers of Michigan citizens, members of the scientific community, and representatives of both the legislative and executive branches of government. A remote sensing display was prepared for Rural Michigan Week and for meetings of the Michigan Academy of Science, Arts, and Letters held on the MSU campus in March 1972. This display contained exhibits from NASA; it also showed examples of remote sensing applications provided by the Environmental Research Institute of Michigan as well as related activities of the MSU College of Agriculture and the MSU School of Urban Planning and Landscape Architecture. Another remote sensing display also appeared at a conference of the Michigan Society of Planning Officials held in Traverse City, on October 11-13, 1972.

In addition, examples of remote sensing imagery illustrating its various applications have been provided to a number of agency staff members in the form of individual prints, collections of prints with explanatory material, and technical reports. RB-57 photography has been made available to individual users interested in various areas of Michigan.

3.2. PROBLEM SELECTION

During the first months of the project, more than 20 Michigan-based agencies were asked to cite problems of land and resource use in Michigan which they thought might be amenable to remote sensing application. Their response covered a wide range of suggested applications: natural resource inventory, cultural feature inventory, land use change detection, growth monitoring, inventory updating, impact assessment, and information gathering for general physical planning. Many of these problems were long-range in nature, requiring several years work, while some of those suggested could be accomplished in a few months. A large percentage were described by the proposing agency as important needs but with no prospect of immediate solution. Frequently suggested by many agencies was a need for a general inventory of natural resources.

The problems eventually selected for first-year application had these characteristics: a clear definition of the anticipated final result; a proponent within the agency, capable of vocalizing the need for that problem's solution; a need for solution within a relatively short period of time; general applicability to other situations, and a definite possibility of collecting the information needed through use of advanced types of remote sensors.

Two major applications were chose for the first year's effort. The development of impact assessment techniques and applications to the route of the M-14 freeway extension is summarized in Section 4, and discussed in detail in Ref. [1]. The development of a management inventory of resources at the Pointe Mouillee State Game Area is described in Section 5. Once these problems were selected, general contracts for the purpose of identifying future applications continued at a reduced pace. The project staff moved into a stage of more detailed problem definition and agency involvement in the research itself.

The principal client agencies most directly involved were two: the Environmental Liaison Unit of the Michigan Department of State Highways (MDSH); and, within the Michigan Department of Natural Resources (DNR), the management staff of the Pointe Mouillee State Game Area. The project staff depended in large measure upon personnel of these agencies to assist in defining the objectives of the overall research, the format of the information needed, the desired end result and, when results were obtained, to provide verification and evaluation. Meetings for these purposes were held periodically throughout the investigations. The final evaluation process has yet to be completed for these two efforts; preliminary evaluations and redirection of effort have occurred several times to date. Agency personnel have provided equipment necessary to accomplish ground truth collection, and—in the Pointe Mouillee study—boat transportation.

3.3. EXPERIENCE IN APPLICATION DEVELOPMENT

The first step in interesting a government agency in remote sensing is to identify to that agency specific problem areas where remote sensing information can be effectively used. Project experience indicates that if there is a realistic prospect for obtaining useful results by adopting remote sensing technology, the necessary interest on the part of agency personnel is usually forthcoming.

Nonetheless, it is necessary to exercise judgment in selecting and defining applications. A clear definition of the problem as well as of remedial objectives should be formulated in advance. The applicability of remote sensing varies from problem to problem. In many cases, there is an urgent need for land resource information which can be supplied by remote sensing. But where decision making is primarily based on social or political factors, land resource information becomes only one factor in the decision-making process.

The problem-solving capability of remote sensing in the particular application of interest must also be kept in mind. Here, the user's needs dictate the types of information to be provided and the descriptive detail necessary. The plan should avoid the tendency to propose collection of information not needed by the user, or to suggest that terrain be identified and mapped in greater detail than justified by the application.

Although the development of interest and activity occurs naturally as information on remote sensing becomes widely disseminated, the rate at which the new technology reaches the stage of useful application can be speeded through organized efforts to develop operational uses. The translation of interest into effective action, however, requires a substantial agency effort. The interest of a government agency increases in proportion to its direct involvement in remote sensing activities. When an agency has committed funding to the program and is actively participating in problem definition, collection of ground truth, auxiliary information and interpretation of results, agency attention is focused on project results and the agency becomes encouraged to consider additional uses.

A necessary requirement in transferring the essential technical background on remote sensing to a government unit is the direct involvement of one or more members of that unit. Either by special assignment or as a result of personal inclination, one or two individuals in a particular unit often take the initiative in studying the technical literature, attending special courses or symposia, and relating this information to their own problem areas.

The user needs a thorough understanding of remote sensing application and interpretation techniques in order to make best use of the data gathered. Conventional aerial photography can be more effectively used through additional training in photointerpretation. The newer and more specialized sensing methods require special technical training so the user understands the physical principles involved and can thus interpret and apply results. Full utilization of remote sensing technology lays stress upon modelling and predictive techniques, many of which increase the value of the data and should be fully exploited. These techniques apply basic physical and biological principles to reach quantitative conclusions concerning existing or predicted conditions; hence they are often essential to the full utilization of available remote sensing technology.

Another requirement for establishing a remote sensing program at an effective level is the ready availability of remote sensing imagery. Acquisition of conventional aerial photography is already a well established practice. With the initiation of NASA's Earth Resources Technology Satellite program and the EROS Data Center, other types of remote sensing imagery will also become more easily available. Imagery from special airborne sensors, such as the multispectral scanner and radar, must also be brought into more widespread use.

4
HIGHWAY IMPACT ASSESSMENT

To evaluate the environmental impact of highway construction, a test site northeast of Ann Arbor, Michigan, which includes a section of existing M-14 freeway built in 1964 and a projected extension of this freeway to Plymouth, Michigan to be started in 1973 (Fig. 1), was selected for study. Remote sensing data included multispectral scanner imagery taken from altitudes of 600 m and 2100 m, RB-57 photography taken from 20,000 m, and other aerial photography. The Michigan Department of State Highways and local government agencies also cooperated in supplying much useful information. Other sources of information included soil surveys, topographic maps, soil and water samples, and ground measurements of surface temperatures and spectral characteristics.

The study showed that only minor effects on vegetation, soils, and land use occurred in the existing M-14 corridor. In the corridor for the proposed extension of the freeway, some adverse changes in plant communities and water levels will probably occur. These effects can be minimized by proper design of drainage ditches and attention to good construction practices. The conversion of agricultural and forested land at new interchanges to residential, commercial or industrial development is anticipated from the presence of the completed highway link to the Detroit area.

The investigation indicated that remote sensing methods can be used to collect and present certain types of data useful for highway impact assessment on land use, vegetation categories and species, soil properties, and hydrologic characteristics. Four major categories of vegetational state (forest, brushland and mixed cover, herbaceous perennials, and annuals or bare areas) were mapped from interpretation of aerial photography. Aerial photography also allowed a study of land use changes occurring over the nine-year period since the existing freeway section was built. Soil surveys provided information on soil texture, natural drainage, and surface slope.

For demonstration purposes, only the most fully developed scanner methods were used. Surface water distribution can be mapped. Various classes of natural drainage of the soil can be distinguished where bare soil is discernible, but results derived from remote sensing interpretation should be carefully field checked. General categories of vegetation can be mapped as well as individual species.

A number of additional methods of scanner analysis are under development in connection with other projects and should eventually be considered for adoption. These methods are

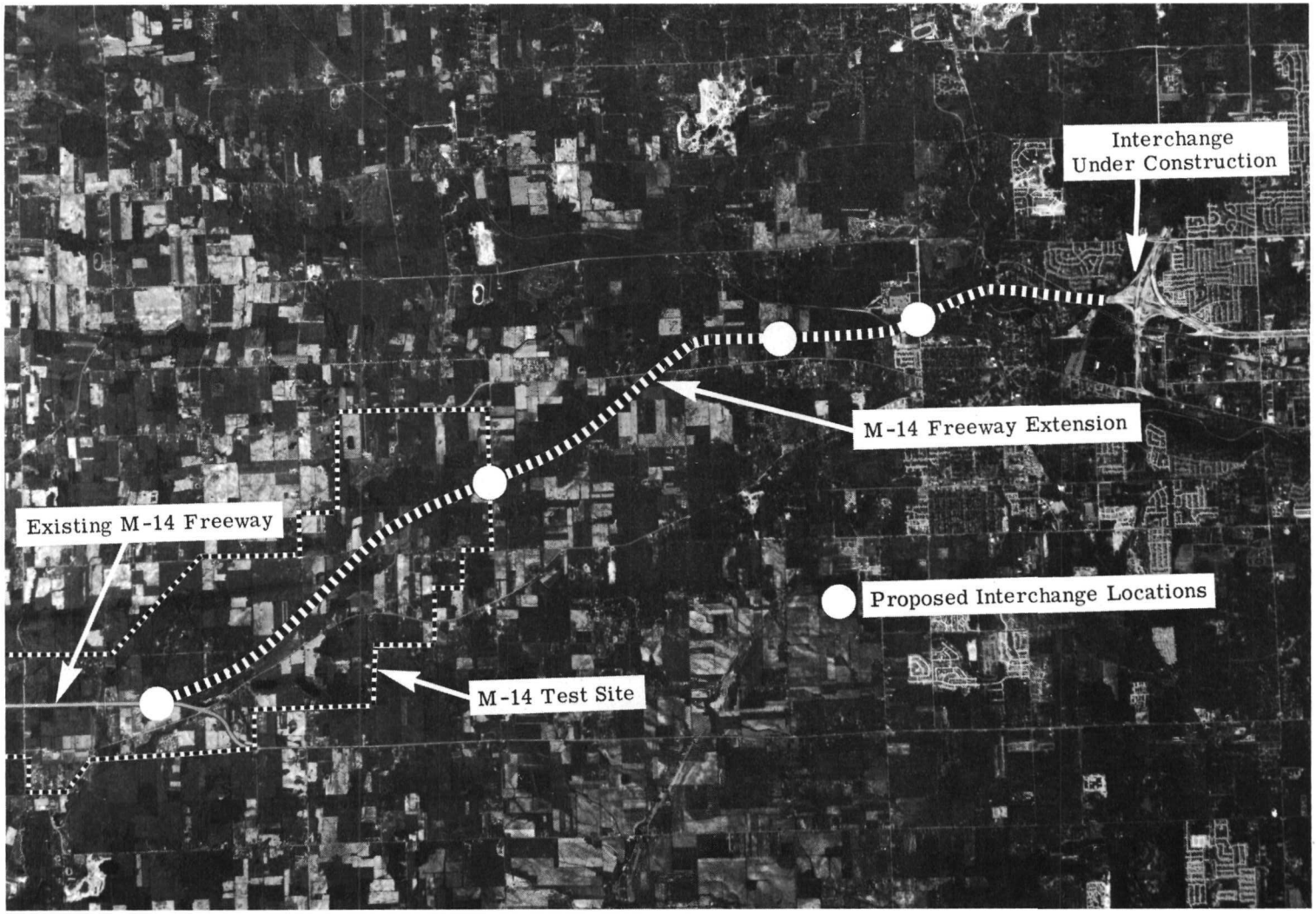


FIGURE 1. M-14 FREEWAY EXTENSION FROM ANN ARBOR TO PLYMOUTH, MICHIGAN

intended for the measurement of soil moisture and the mapping of soil texture and sensitive vegetation species.

Maps of soils, vegetation, topography, surface water, and land use can be prepared in the form of a base map and sets of transparent overlays allowing the character and spatial relationship of these various surface features to be readily displayed and compared.

The M-14 study was performed in cooperation with the Environmental Liaison Unit of the Transportation Planning Division, Michigan Department of State Highways.* The Unit, which is charged with carrying out evaluations of the impact of highway projects throughout the State of Michigan, provided guidance by defining its responsibilities and current practices, recommending an appropriate test site, and reviewing investigation results. (The results reported herein, however, do not necessarily reflect the views of the Department.)

The work on highway impact assessment is reported in Ref. [1], a supplementary technical report. Detailed information is given on the investigation procedures, results and conclusions. Recommendations are made for further evaluation of the most effective remote sensing techniques for highway impact assessment.

*The assistance given the project by G. Robert Adams, Supervisor, Environmental Liaison Unit, and Jan H. Raad, Environmental Specialist in the Unit, is gratefully acknowledged.

5
WATERFOWL HABITAT MANAGEMENT

The Pointe Mouillee State Game Area and the area surrounding it comprise the test site for the investigation described in this section. The investigation used remote sensing to provide information needed for the effective management of a natural area as waterfowl habitat.

Information derived by means of remote sensing techniques can be of use to those concerned with game area management in several specific ways. The game area manager needs current information to aid him in making daily decisions concerning the operation and management of the area. Permanent records of such information are also valuable in making longer range plans concerned with area maintenance and improvements. In addition, quantitative and pictorial information in the possession of the game area manager can provide evidence to other technical and administrative personnel and to the public when problem solution requires their support.

This investigation has been conducted in close cooperation with Mr. James Foote, Game Biologist for the Department of Natural Resources stationed at the Pointe Mouillee State Game Area.* As remote sensing results are obtained, they are reviewed with Mr. Foote to assist him in making operational and planning decisions and to obtain his evaluation as to the usefulness of the remote sensing data in his particular application.

Results are also being reviewed with other administrative and technical staff members of the Michigan Department of Natural Resources. These reviews are designed to help DNR evaluate the role of remote sensing as an aid in the solution of present and future problems.

The first phase of this investigation was initiated under the contract covered by this report. Work is continuing under the follow-on grant, and final results will be published in a separate technical report. At present, as this annual report is being written, much of the data collection and analysis has been completed so preliminary results can be reported.

5.1. SITE DESCRIPTION

The Pointe Mouilee State Game Area is located on the delta and estuarine area of the Huron River as it enters Lake Erie just south of Detroit (Fig. 2). The game area, which presently consists of 1100 hectares of publicly owned land, is an important feeding and resting area

*Mr. Foote was extremely helpful in providing information concerning the operating practices and information requirements for successful management of the area and also in assisting with the collection of ground truth.

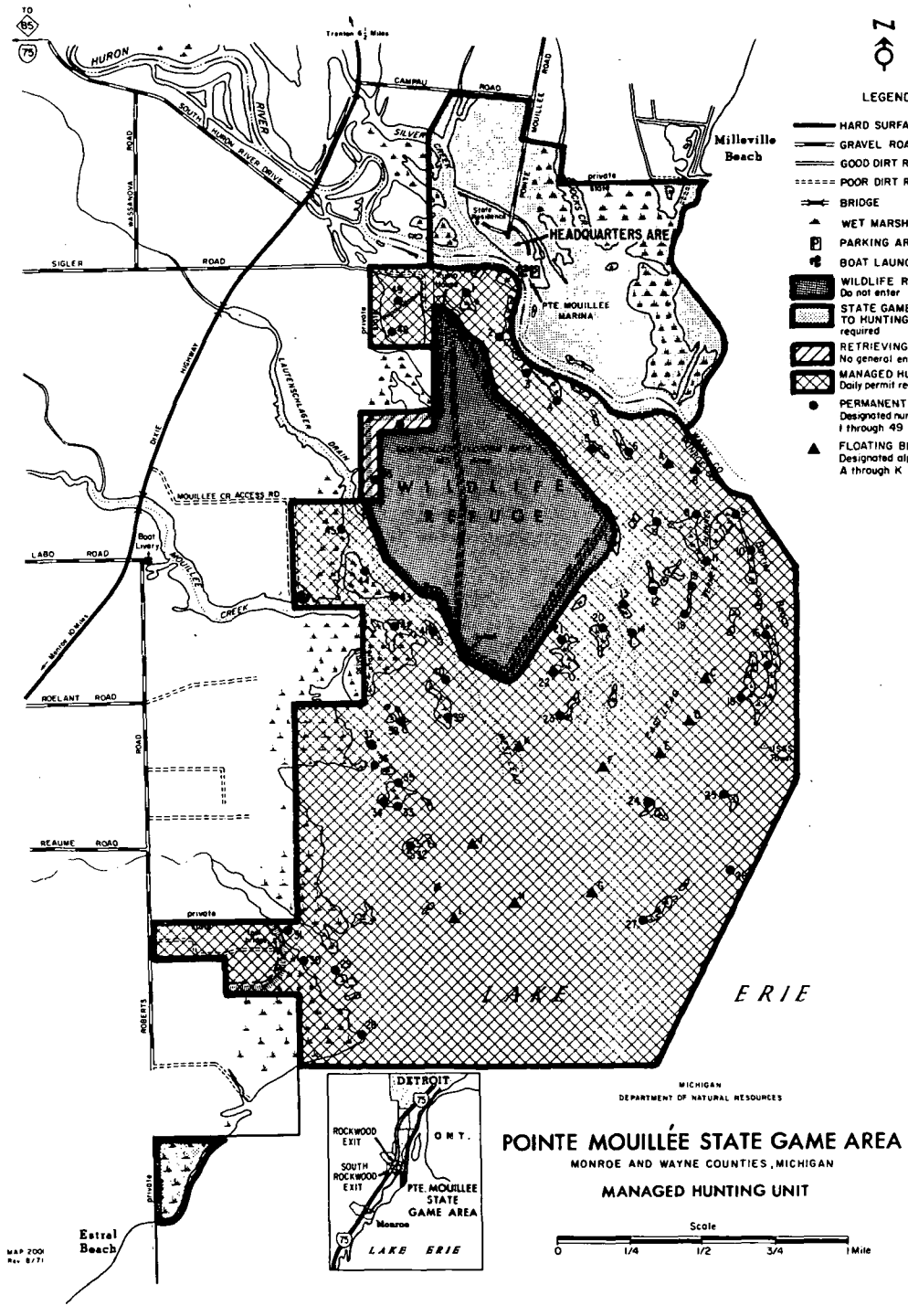


FIGURE 2. POINTE MOUILLEE STATE GAME AREA

on migration routes for waterfowl, a nesting area, and one of the few duck hunting areas in Southeast Michigan. It is also one of the only two environmentally healthy marshland areas and wildlife refuges left on Lake Erie. Like all estuarine habitats, it plays a vital role in maintaining the bioproductivity of the lake. Within the State Game Area, a large diked area is actively managed as a wildlife refuge. Pumping units regulate the water level within the dike. The area is drained in the spring so that food for the ducks (e.g., smartweed and millet) can grow and mature; in the fall it is flooded.

A chief concern to Michigan's DNR is the rapid destruction of the marsh delta at the mouth of the Huron River. Dams constructed over the years at various upstream points have effectively blocked the normal silt and sediment load of the river; this has prevented the natural flow of materials to the marsh delta needed to replace those materials continually lost by current flow and by wind and wave action of the lake.

Various human activities also threaten the continued operation of the State Game Area. The Game Area has been under pressure in recent years from encroaching residential development. Moreover, during the 1960's the construction of large manufacturing complexes in the immediate vicinity was proposed. To buffer this potential industrial development from the marsh areas, the Department of Natural Resources acquired 200 acres north of the Huron River. The eventual plan is for the Huron Clinton Metropolitan Authority to fill in this site and to construct a park. At the time Pointe Mouillee was selected for a remote sensing investigation, the Corps of Engineers had proposed to use these same lands for dumping material dredged from the Detroit River Channel. However, because there was concern for loss of natural marshland and for the possible environmental effect of dumping material with an appreciable mercury content, the Corps of Engineers postponed its plans. Other changes in land use or in environmental factors affecting the marsh area may result from the proposed construction of a thermal power plant nearby and a regional wastewater treatment plant in the vicinity.

The viability of the Pointe Mouillee State Game Area is seriously threatened from both natural influences and man's activities. Unless action is taken within the next few years, the habitat will cease to function as a recreation area for hunters and will eventually decline in value as a waterfowl refuge.

5.2. INVESTIGATION OBJECTIVES AND PROCEDURES

The major goal of the wetland assessment and management policy study of the Pointe Mouillee State Game Area was to provide information needed for solution of the management problems just described. As a result of several discussions with Game Biologist Foote, a program was designed to collect and analyze remote sensing and other information for these specific purposes: (1) measurement of past and present island and shoreline destruction, (2) inventory and evaluation of land adjacent to the marsh area as potential replacement for this destroyed habitat, (3) inventory and assessment of vegetation used as food and cover, (4) mapping of submerged aquatic vegetation, and (5) mapping of shoal areas.

Our study of the Pointe Mouillee State Game Area includes four investigative phases. During the data acquisition phase, aerial photography, multispectral scanner imagery, and ground truth data were collected. In addition, a preliminary bibliography of specific information on Pointe Mouillee as well as general information on current wetland assessment methods were compiled for use during the data interpretation and analysis phases. Aerial photography used in the study included high-altitude vertical photography, low-altitude vertical photography, and low-altitude oblique photography.

The high-altitude photography was available from three RB-57 flights (1969, 1971, and June 1972). The high-resolution quality of this photography allowed enlargements from which a photo-map substitute was produced for reference purposes. The photography was also useful for shoreline delineation and for coverage of upland areas around Pointe Mouillee.

Low-altitude vertical photography was obtained from C47 aircraft flights. Efforts have also been made to obtain coverage from other sources, such as the Department of Natural Resources, Department of Agriculture, and Corps of Engineers. This additional imagery from previous years was used to show shoreline and vegetation changes. Photography from the C47 flight was available in formats of 70 mm and 9 in. (22.9 cm) at scales of 1:8,000 and 1:4,000. The 9 in. color infrared photography was most useful, especially for surface vegetation analysis and the inventory of the adjacent lands.

Evaluation of low-altitude oblique photography obtained by hand-held camera from a helicopter allowed the specification of operational mission requirements for photography collected during the C47 flight in August 1972. The photography was also used as a supplement to smaller-scale photography when the scale or type of film prevented accurate interpretation of a specific target.

Two flights were conducted over the area with the NASA-supported C47 aircraft. Mission 54M was flown on 5 May 1972 with flight lines at altitudes of 610 m and 1220 m. Because this flight was made early in the growing season, it was of limited use for vegetation mapping. A second flight at 1220 m was made over the area on 29 August 1972 (Mission 64M) at a time when most vegetation was green. During both flights, multispectral scanner data were collected and supplementary aerial photography was obtained. During the second flight, the 9-in. color infrared photography was obtained.

Ground truth collection entailed the recognition of unidentified objects of areas, detailed surveys of specific areas, and verification or evaluation of the remote sensing interpretation. The ground truth collector aided the interpreters in their choice and definition of representative areas to serve as training sets for scanner imagery analysis. To accumulate this information at Pointe Mouillee, several transects were made within the diked portion of the marsh. Vegetation types, height of the vegetation, and bottom contours were noted. After the training sets were established and the photointerpretation begun, the ground truth collector aided the interpreters through field identification of unusual objects or patterns which were unclear or not easily discernible by the interpreters.

Multispectral scanner data from both C47 flights were processed by means of existing methods of thermal level slicing and spectral analysis and recognition. Specific results of this processing are discussed in following sections.

During the data processing phase, an up-to-date base map of Pointe Mouillee was constructed. This was essential since the existing USGS maps of Pointe Mouillee do not show the present configuration of the shoreline. A reference map was constructed by transferring inland lakes, roads, buildings and contours to a work sheet and plotting the present shoreline and any other changes on this reference map with the 9 in. color infrared photography and a Zoom Transfer Scope. These procedures yielded an up-to-date basemap of Pointe Mouillee at a scale of 1:8,000 which graphically depicts the inventory results.

5.3. SHORELINE EROSION AND LOSS OF MARSH HABITAT

The chief concern of DNR game managers is the rapid destruction of the marsh delta at the river mouth. Construction of upstream dams has prevented the natural flow of materials needed to replace those materials lost to current flow, wind and wave action. East winds drive high water from the lake into the mouth of the river, uprooting cattails and washing away complete islands.

To determine long-term changes of marsh habitat, a study was made of past records of the area. These records consisted of both aerial photographic coverage obtained at various times and bibliographic references on past studies of the area. A series of maps was constructed which depict the change in shoreline configuration for the past four decades.

The appearance of the Pointe Mouillee area in 1935 is shown in Fig. 3. By 1972, the area had changed drastically (Fig. 4). Measurements taken from area maps indicate that 65 hectares of marsh delta were lost from 1940 to 1967. From 1967 to 1972, an additional 290 hectares were lost. Additional losses were sustained as a result of severe flooding of the western shoreline of Lake Erie during the fall and winter of 1972-73. This flooding was particularly destructive because of the high water levels existing in Lake Erie. No quantitative measure of the most recent damage is available but it is known to have appreciably altered the shoreline in the vicinity of Pointe Mouillee. Our review indicates that the rate of marshland destruction has accelerated significantly in recent years.

These findings substantiate the importance of these parallel DNR policies: (1) to resist and, if possible, counter the pressures arising from conflicting land use trends in the vicinity of Pointe Mouillee, and (2) to acquire and develop additional land suitable as waterfowl habitat.

The use of remote sensing for identification and monitoring of extensive losses of barrier islands and cattail beds also provides a basis for predicting those marsh shoreline locations most in need of protection. Large areas of dead vegetation, an indicator of impending destruction of shoreline, have been identified and brought to the attention of DNR staff for their action.

FIGURE 3. POINTE MOUILEE, 1935

FIGURE 4. POINTE MOUILLEE, 1971. RB-57 Aerial Photograph.

Areas where little or no shoreline destruction has occurred over the past three decades have also been identified, and should be studied further to determine possible reasons for their durability.

5.4. EVALUATION OF ADJACENT LAND FOR FUTURE MARSH HABITAT

Because of the rapid and irreversible destruction of the marsh delta, areas suitable for future marsh habitats must be found. For this reason, the project staff in consultation with DNR officials concluded that evaluation of the upland region immediately to the west of the diked area would be important. The Department of Natural Resources has already purchased some of the property adjacent to the marsh and plans to purchase additional property for marsh habitat as well as to serve as a buffer against nearby residential and industrial growth.

The main decisions facing the game manager are to identify potentially suitable habitat and to select the order in which individual fields are converted to marsh situations. (The conversion process consists of constructing a dike—so that water levels can be controlled—and then growing vegetative species suitable as food and cover for waterfowl.) These decisions require: current land-use information, soil and topographic analyses, and the location of areas exhibiting habitat characteristics suitable for ducks (especially standing water, cattails for cover, and food).

Accordingly, we constructed a general vegetation cover map of the adjacent land, performed a land use inventory, and completed a soil and hydrology inventory. This information was transferred onto copies of a previously constructed base map which included contour lines depicting elevation.

We also obtained information from scanner data. Figure 5 shows a computer map derived from scanner imagery. This map, though containing only a partial printout of area features, can be used for habitat evaluation. The diked area is in the center. The various symbols show the distribution of cattails, bulrushes, and sedge grasses providing useful cover for ducks along the shoreline west of the dike.

Figure 6, derived by scanner data processing, shows additional information on this area. Features of particular interest are the land-water boundaries. The two water masses near the shoreline have different origins and different foreign material content; if it were necessary to determine the presence of pollutants which might affect the suitability of adjacent land, these differences in water masses could be mapped and analyzed in much more detail. Techniques are available to locate individual water masses, which may be distinguished by silt and/or sediment load, algae content, and other factors affecting water chemistry. Surface temperature can also be mapped. Because the mapping of water quality was not of immediate concern in the investigation, it was not attempted.

5.5. VEGETATION INVENTORY, CLASSIFICATION, AND MAPPING

The erosion of marshland area would be even more serious if it had not been partially counteracted by the construction of the dike shown in Fig. 1. The diked area, consisting of 148 hectares of land, was originally constructed to impound water in what was then a dry area. With the continued erosion of the delta, the dike has become completely surrounded by water and is the only area actively managed to provide food and cover for waterfowl. An inventory of vegetation within the dike is therefore very important as an aid to management decisions.

Up to the present time, limited information about vegetation types has been collected, with no attempt at quantitative measurement. Continuing information on vegetation and other conditions in the dike is needed as a means of monitoring the effects of management practices. Since these results occur only after extended periods, practical methods for repeating the inventory are essential.

The remote sensing investigation therefore concentrated on the preparation of an inventory and mapping of aquatic vegetation in the marsh area as means of recording the current distribution and condition of this vegetation.

A detailed vegetation classification map of the Game Area was prepared from aerial photography and intensive field studies. The vegetation within the dike was mapped using a relatively detailed classification scheme to show 20 categories of vegetation and land cover (Fig. 7). The identifications of vegetative cover areas were made on the 9-in. color infrared photography at a scale of 1:4,000 and were transferred onto an overlay, thus giving a vegetation cover map of the area within the dike. Ground truth collection provided transect data for vegetation indentification and was also valuable in determining factors which control plant community location.

This effort also aided in the location and identification of training sets for the computer processing of scanner imagery (Fig. 8). The dike is divided into two unequal parts, the eastern section being much larger than the western section. The eastern section is at a lower elevation and therefore produces more food. The western section is drier, containing extensive areas of upland grasses. For these reasons, each section was treated separately in scanner processing, and vegetation classification was performed on those classes that either dominated in areal extent, or were singled out as important food and cover sources. The inventory and mapping of vegetation, including both the photographic interpretation and scanner recognition maps, constitute the first significant research results on this area since 1951.

The resulting information has already been applied for management purposes. The detailed inventory of the natural and managed vegetation of the marsh has indicated to DNR a number of areas where species of vegetation undesirable for duck food predominate. DNR will concentrate its efforts in these areas to introduce more suitable vegetation, such as smartweed and pigweed.

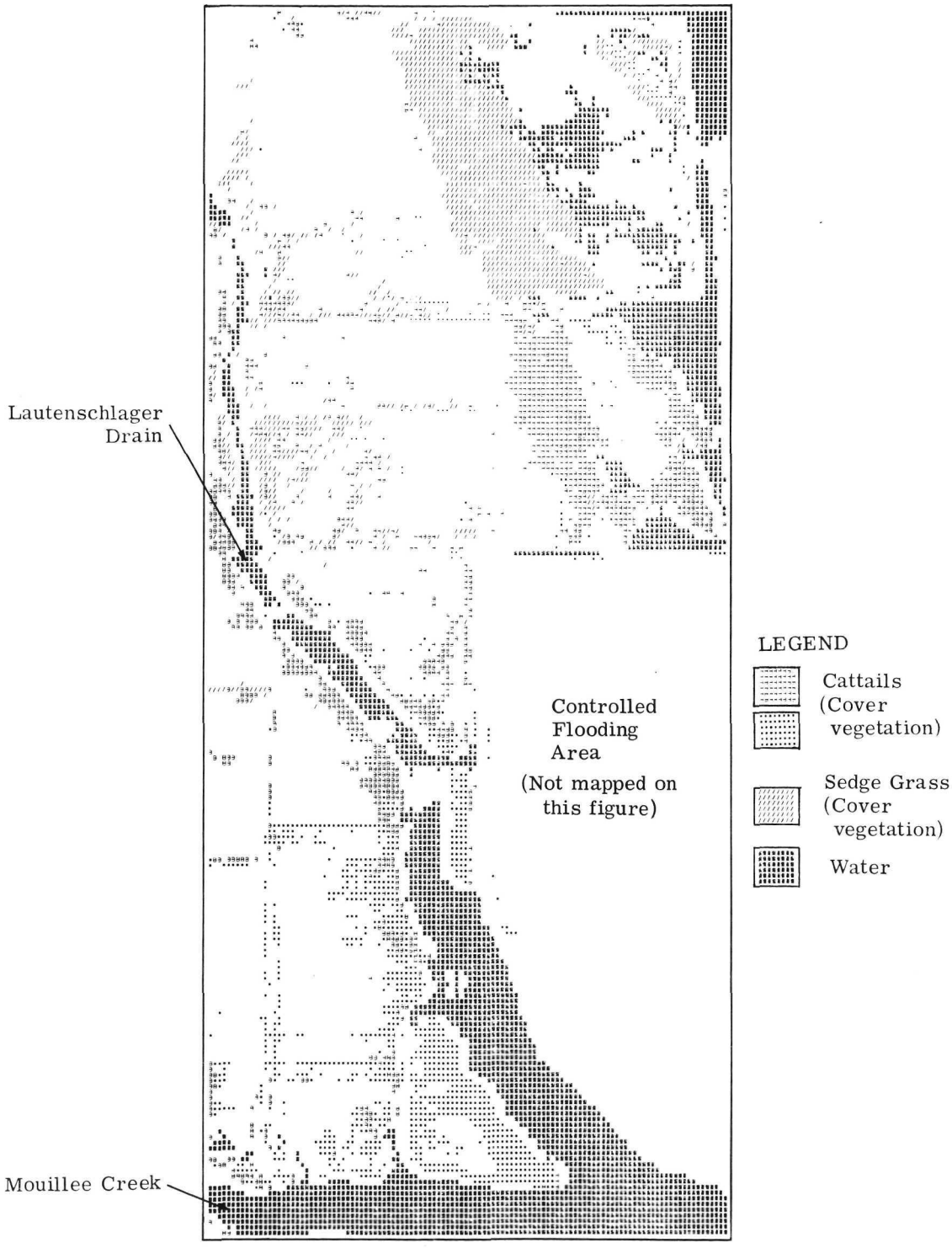


FIGURE 5. VEGETATION ANALYSIS FOR MARSH DEVELOPMENT

FIGURE 6. LAND-WATER BOUNDARIES OF ADJACENT SHORELINE

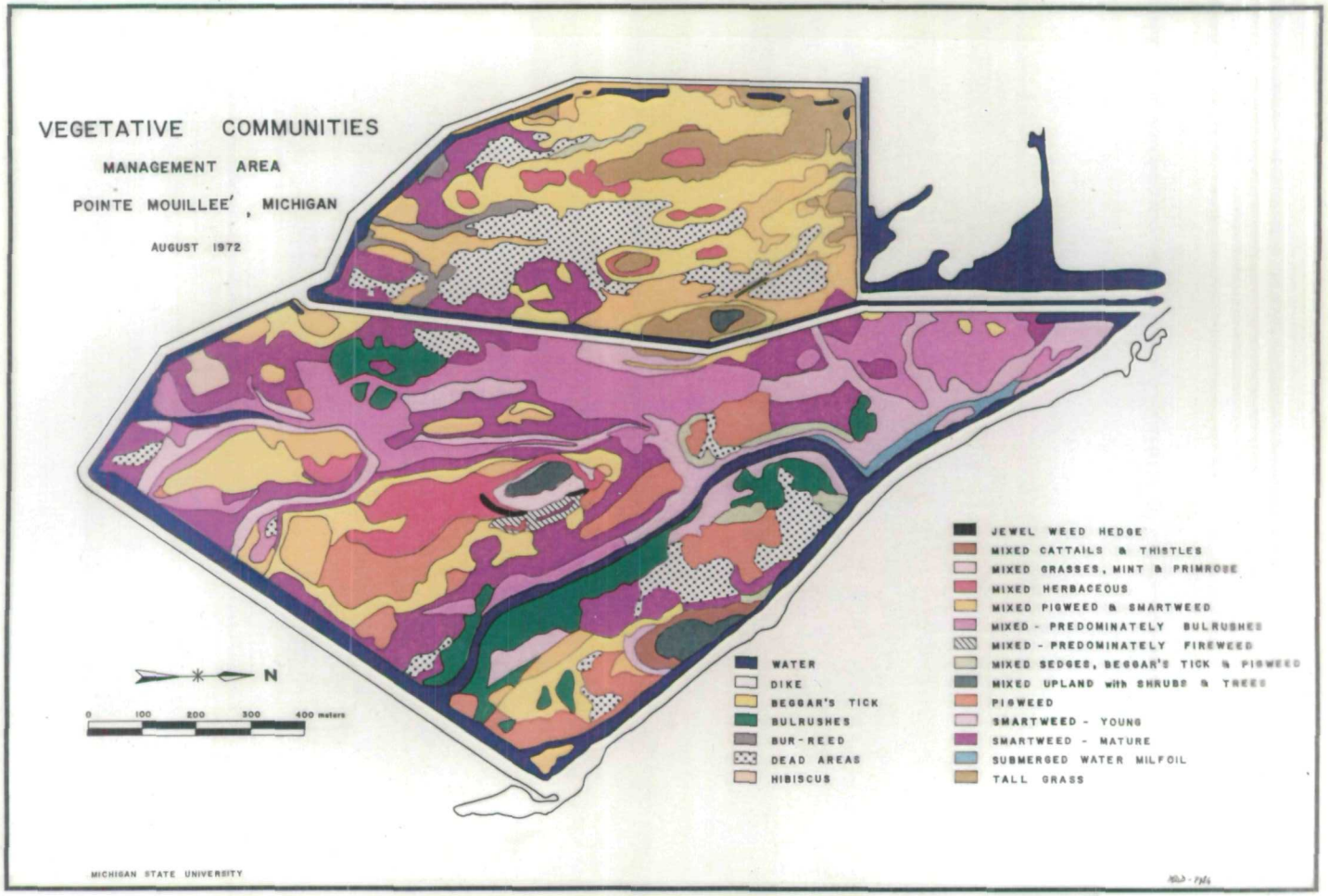
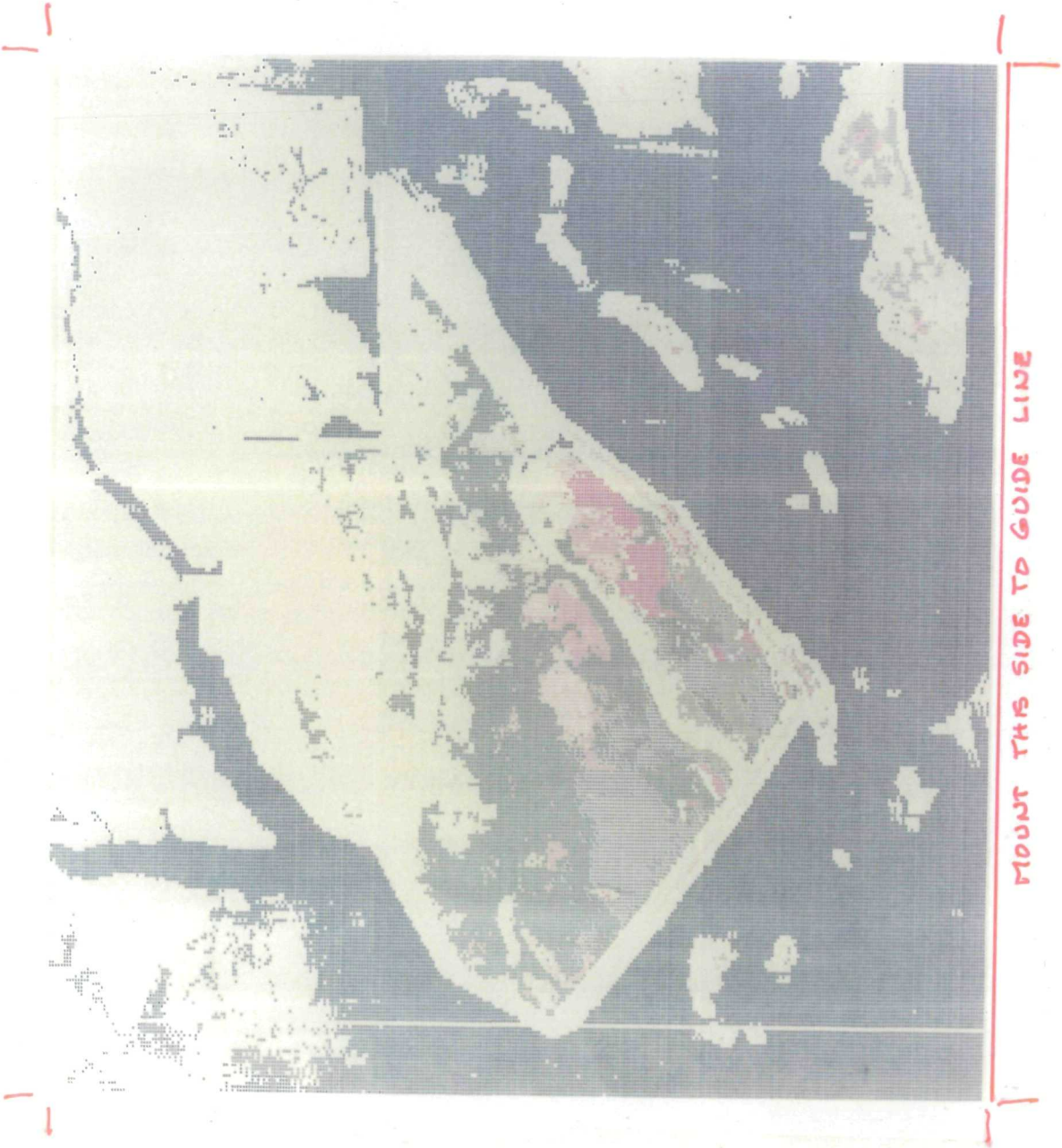


FIGURE 7. DETAILED VEGETATION MAP OF CONTROLLED FLOODING AREA



LEGEND

Dark Red - Dead Vegetation
Light Red - Smartweed (food)
Dark Green - Mixed Smartweed and Pigweed
Light Green - Mixed Grasses
Blue - Water

FIGURE 8. MAP OF FOOD AND COVER VEGETATION IN CONTROLLED FLOODING AREA

Large areas of dead vegetation, mapped from remote sensing imagery, indicate those areas where flooding procedures must be improved. Upland plant communities identified through this research need to be replaced by more desirable plant series.

5.6. SUBMERGED VEGETATION

Information is also needed on submerged aquatic vegetation (e.g., wild celery and potopiagetian) important as food for ducks. Substantial areas of submerged aquatic beds are located at various points near Pointe Mouillee and at the mouth of the Detroit River near Celeron Island. This aquatic vegetation exists in patches typically 0.2 hectare in extent, and information is desired on vegetation lying at depths of as much as 3 m.

Maps showing the distribution of submerged aquatics provide needed information on the amount and condition of the food available for ducks. Early detection of vegetative community destruction might also be provided by remote sensing. Maps showing the distribution of submerged aquatics also provide information which may be used to infer bottom conditions. The location of shoals is also of interest.

The study of submerged vegetation and shoal areas has been given less attention than other study objectives. Color infrared photography has been examined to determine general patterns of underwater vegetational growth. Water milifoil, algae, cattail, and bur-reed are among the vegetation types noted on the photography.

5.7. APPLICATION OF RESULTS

The results of this study are being reviewed with game area management personnel at Pointe Mouillee and at other units within DNR. The information developed by these studies should prove effective in highlighting the problems resulting from the continuing loss of marsh habitat and in developing a program for countering these problems. The information should also be valuable for improved management of those areas currently providing vital food and cover for waterfowl.

6
LAND USE AND NATURAL RESOURCE INVENTORY

6.1. LAND USE POLICY DEVELOPMENT IN MICHIGAN

The formulation and implementation of a state-wide land use policy is being actively undertaken in Michigan. In 1971, the Governor's Special Commission on Land Use issued its recommendations for a program of land management by the state [2]. The suggested program would include longer range management objectives and shorter range activities for preservation of land from undesirable patterns of development. Positive programs are urged to locate highways, utilities, airports, and other capital investments in strategic locations of desired growth as a means of creating economic pressure to catalyze other development. Appropriate taxing and financing policies are also required to ensure the achievement of desired management objectives. Since these are long-range suggestions, the recommendations also include restrictive measures such as zoning and permit requirements to prevent misuse of land in the interim period.

A fundamental task in land use management is that of assigning land for its optimum use in meeting social and economic needs, in accordance with criteria established for protection of the environment, maintenance of health, and cultural values. The land use assignment problem requires basic decisions concerning the reservation of lands meeting the criteria of open space districts—including prime agricultural land, forest land and recreational land. Good planning avoids taking over land for the expansion of existing cities or creation of new communties which should be preserved for agricultural or recreational use. It will also avoid building in areas which are unsuitable because of potential flooding, impermeable soil, or unfavorable topography. Suitable sites must also be selected and reserved for commercial and industrial expansion, airports, highways, solid waste disposal and other necessary purposes.

At the direction of the Governor, the State Planning Division in the Bureau of Programs and Budget is further defining the land management policy to be recommended for adoption by the State. Although features of the overall plan are still being studied, the implementation of the management plan is certain to require an organized body of data on land use and natural resources throughout the state as a basis for intelligent decision making.

Such information is needed for many purposes. It constitutes an up-to-date record of the type and distribution of the state's land use and natural resources. It provides data useful for monitoring trends in land use over extended periods of time. It also furnishes a basis for land evaluation needed for reservation of land for its optimum use. Site selection, planning of utili-

ties and services, resource management, and environmental protection are additional functions which can be well served by an adequate information base.

6.2. PROJECT ASSISTANCE IN LAND USE MANAGEMENT PLANNING

Because of the growing urgency of the problems of land management, the project staff devoted considerable attention to the potential application of earth resource survey technology for gathering and organizing the data on land resources needed for this purpose. The staff has actively assisted the State Planning Division in developing a state-wide policy plan for land management and in providing advice on the use of remote sensing for developing and implementing such a plan.

The MSU project staff provided direct consultation on research program design, funding proposal development, and information system development. Recommendations have been made concerning government efforts to standardize mapping and land use classification procedures.

ERIM staff members recommended a short-range program of land use mapping needed for an initial record of the state's land use and natural resource distribution. As a result of the project's early participation in the overall planning, the State Planning Division has provided separate financial support to ERIM to carry out three tasks:

(1) To prepare a land use map of the entire state from currently available photographic coverage and other information. This map shows four major categories of land classification (urban, water areas, forest, and "other" including agriculture) at a scale of 1:500,000

(2) To use ERTS-1 coverage of the state, as such imagery becomes available, to check and update the land use map

(3) To prepare an updated land use map and a land use change detection map of the Lansing Tri-County Region at a scale of 1:62,500 with available RB-57 photography

This initial participation by the project in state land use management programs is expected to continue into later phases of program implementation. More detailed land inventory collection and information management systems will be required, and the project can provide consultation and support concerning applications of remote sensing for developing this information base and applying its results to the land management problem.

6.3. INVENTORY STORAGE AND RETRIEVAL SYSTEMS

Where information on surface features of the earth is required for the study of a specific isolated land resource use problem, direct analysis and interpretation of remote sensing imagery is normally practiced. For many purposes, however, it is advantageous to collect and organize information on surface features into a comprehensive inventory of land use and

natural resources. This discussion is concerned particularly with the use of remote sensing as a source of information for the preparation of such inventory data.

Implementation of a state land management program will require logical, systematic methods of handling the vast amounts of information obtained in an inventory of land use and natural resources. Data storage and retrieval systems needed for this purpose should be economical, accurate, and easy to use. In addition, convenient and economical means of portraying the data for the user should be provided. To facilitate standard cartographic methods of presenting data, the storage and retrieval system should permit either drafted or computer maps to be made quickly and inexpensively.

The recent trend of state, regional, county, and municipal planning bodies in Michigan and elsewhere is toward the installation of computer-based information systems for storage, retrieval, and statistical analysis of data needed for land management [3]. For this purpose, substantial effort is spent on assembling and maintaining up-to-date records. Any consistent and reliable source of information which can supplement existing methods of gathering data can aid the economy and effectiveness of existing systems. Planning officials contacted by the project staff consistently indicated the need to use remote sensing to maintain better records of land use and resources, to update and check existing maps and records, to note patterns of urban growth, and to make statistical projections of trends in land use or population.

Work already done on the project at the M-14 Test Site offers some applications appropriate to this problem. Although the primary focus of the work was the collection of resource data related to highway impact assessment, the results were useful as examples of the types of data available from remote sensing for land inventory and evaluation processes and of methods of organizing and recording such data. In particular, the M-14 work led to the selection of a specific land classification scheme which can be adapted to more general use. It also produced a coordinated set of data records for a test area on broad categories of vegetation and important soil parameters. These preliminary efforts can later be expanded to meet the goals of state land management described previously. The results of this work have been brought to the attention of the State Planning Division for consideration of applicability to its land management planning responsibilities.

For land use and resource studies of relatively small areas, various cartographic forms of presentation may be suitable. One possible form of cartographic presentation of inventory data consists of a set of base maps and transparent overlays on which various forms of terrain data are recorded. This form of recording and presenting data was used in the highway impact assessment study at the M-14 Test Site and is described in detail in Ref. [1].

In this form of presentation, each overlay contains a record of a particular factor of significance in land analysis. At the M-14 Test Site, separate overlays were used to record

base map, land use, vegetation categories, soil texture, soil natural drainage, surface slope, and topography. The recording and presentation of inventory data in this form facilitates terrain analysis.

6.4. RESOURCE CLASSIFICATION SYSTEMS

The study and selection of classification systems is a prerequisite to the adoption of remote sensing techniques for mapping and inventory functions. RB-57 photography and computer-processed ERTS-1 scanner data look promising as sources of data for this purpose.

Inventories for land use management must cover all significant aspects of the landscape, including land use, soils, vegetation, and hydrology. Prior to preparing such an inventory, however, classification systems need to be established in order to have a systematic method of viewing and recording the inventory information. Substantial progress has been made toward the completion of a standardized land use and resource classification system. In both the M-14 highway impact study and the Pointe Mouillee area study, classification systems had to be developed and modified to inventory the study areas in a systematic manner. Some of these systems are being tested for state-wide use, while others are applicable only to certain selected sites. Work is continuing to convert them or develop new state-wide classification systems.

Three classification systems were adopted which fit, to some degree, the above-stated criteria for data storage and retrieval, and cartographic presentation. They are: the vegetation classification system, the land use classification system, and the soils classification system. The vegetation classification system was specially designed for computer storage. The land use classification system was modified from a system designed for computer storage and mapping. The soils classification system involved grouping and generalization of soils data for cartographic presentation. These three systems, in addition to a Michigan Department of Natural Resources ground cover classification system, are discussed next.

6.4.1. VEGETATION CLASSIFICATION SYSTEMS

A vegetation classification system was developed in two stages: a gross stage, consisting of four classes for general information, and a detailed stage, which gives large amounts of vegetation information.

The first stage used the following four categories:

Annuals or Bare—Areas in which perennial vegetation covers less than 50% of the surface, except areas with more than 10% shrubby or arborescent cover. This class is assumed to include areas subjected to clearing, building, or hand surfacing by man.

Herbaceous Perennials—Areas in which the ground surface is 50% or more covered by herbaceous perennial vegetation during the growing season, while not exceeding 10% shrubby and arborescent cover. This type encompasses grassland, grass/forb (other small herbaceous plants), and swamp grass vegetative communities.

Brushland and Mixed Types—Areas in which the combinations of vegetation do not meet the specifications for the other three categories. Such areas usually appear as brushland. The cover will include more than 10% trees and shrubs, but less than 50% trees.

Forest—Areas in which 50% or more of the ground surface is covered by vertical projections of tree crowns. For purposes of this classification, an individual plant must be at least 5 m in height to be considered a tree.

The four-category vegetation classification system was used for general mapping of vegetation in the M-14 Test Site (Fig. 9). We concluded that a four-way breakdown according to growth form is convenient for providing general information on vegetative cover. The four categories correspond generally to the successional stage of the vegetation and may thus be taken to indicate, for impact assessment and other purposes, the economic and environmental value of the vegetation. Since this classification is designed to provide generalized rather than detailed information, a minimum type size of two hectares (five acres) is adequate. A detailed discussion of methods for using remote sensing data to analyze and map vegetation categories for this purpose is offered in Ref. [2].

Detailed vegetation information is necessary for advanced stages of land use planning and routine natural resource management, and can be applied to site conditions, stand structure, species composition, and presence of unusual conditions for applicability. Though it is impractical to include this much information on a single map, there is no way of accurately anticipating information needs for possible applications. The basic need is for an information system that will allow any desired portion of the original data to be retrieved in either rough map form or tabular form.

The first step in developing an information system is to decide what the unit record for collecting, storing, and retrieving information will be. One hectare (2.47 acres) seems to be the smallest unit manageable for an information system of this type, but further study is needed before selecting the basic cell size. The Universal Transverse Mercator (UTM) grid is used to define the boundaries of hectare cells. For purposes of collecting data, recently available photography at a scale not smaller than 1:40,000 is desirable. An overlay with the grid lines is prepared for each photograph.

The collection of detailed information on vegetation at the M-14 Test Site was used as a pilot study for developing a prototype of the information system. The following items of data are taken for each cell:

(1) the presence of unusual conditions, either ecological or economic, noted and described verbally

(2) successional stage of the vegetation

(3) percent cover of trees (4.5 m or higher) in aerial view, by deciles

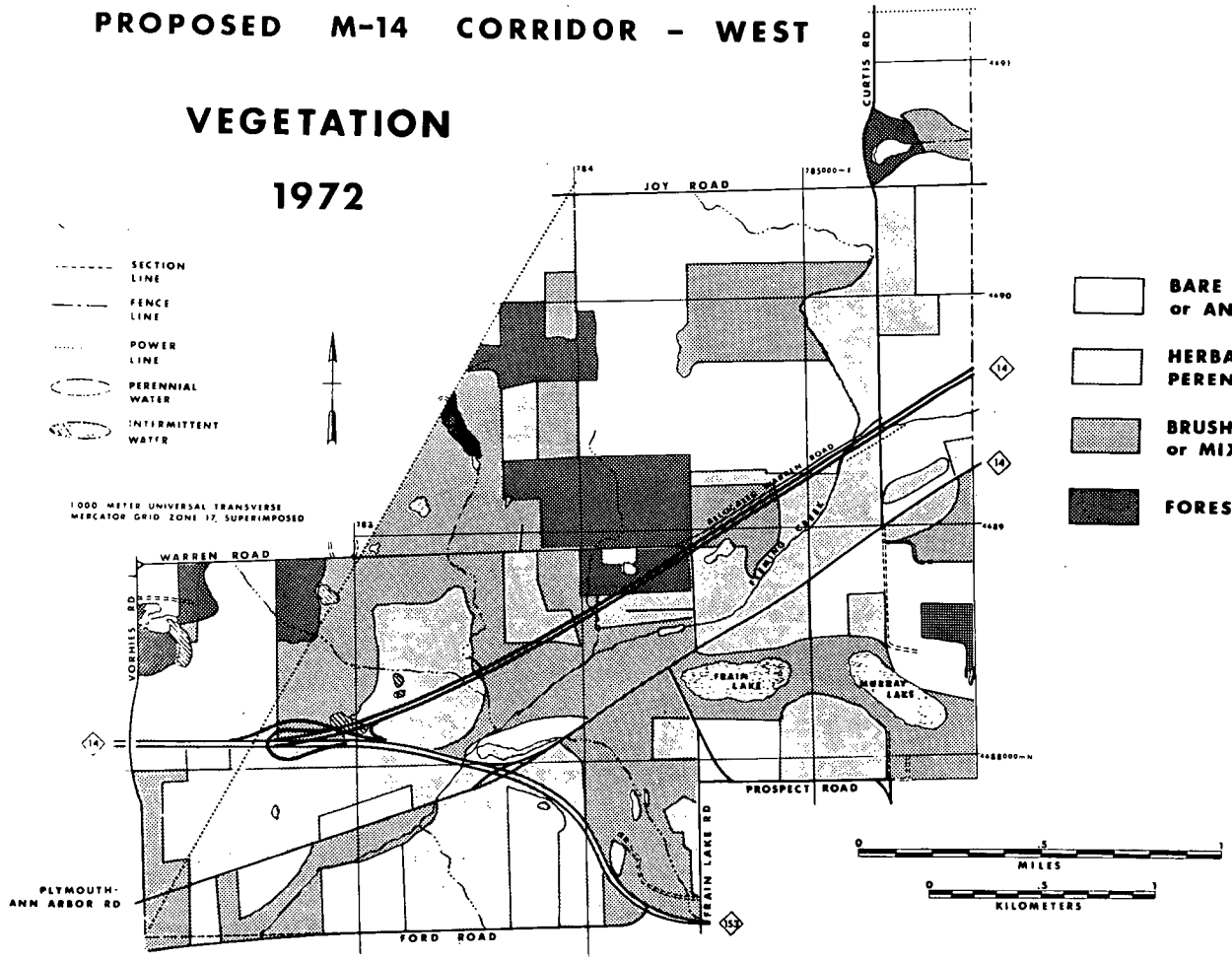


FIGURE 9. VEGETATION MAP OF M-14 TEST SITE

(4) percent cover of shrubs (less than 4.5 m) in aerial view, by deciles

(5) percent cover of herbaceous perennials, by deciles

(6) average height of tallest species, in deciles

(7) uniformity of cover, in quartiles

(8) most abundant species in understory

(9) most abundant species in overstory

For the Pointe Mouillee study area, the Game Division Cover Legend of the Department of Natural Resources system of classification and mapping cover types was used. It uses a combination of letter, symbol, and numbers to indicate site characteristics and plant types. For example:

Site wetness - 1—wet, 2—swamp border, 3—well drained

Dead vegetation - b

Stocking - ' poor, '' medium, ''' good

Two story cover - fraction

Plant species:

O	Oak	L	Locust	Bx	Beach Sand
O_1	Oak-Hickory	L_1	Sassafras	Bx_1	Bare Rock
O_2	Hickory	L_2	Butternut	Bx_2	Mosses
O_7	Pin Oak	L_6	Wild Plum	f	Floating Mat

While this system was found to be very workable and valuable for game cover, it does not include all of the information of the detailed vegetation classification system mentioned previously.

6.4.2. LAND USE CLASSIFICATION SYSTEM

The land use classification scheme used for both the M-14 and Pointe Mouillee studies was derived principally from the Land Use and Natural Resource Project (LUNR) at Cornell University [3]. This system was originally developed to be included in an information storage and retrieval system. This classification system was modified for use on the various studies; categories were eliminated or combined for more efficient evaluation and presentation of the land use data.

One important problem arose as the various classification systems were compared. The categories selected for certain land uses generally do not coincide with those used for the first stage or general vegetation inventory classifications. This may be corrected in the future when the classification systems are modified.

The LUNR land use classification system used is a one-level system, and was specifically designed for New York State. It seems, therefore, that a multi-level system will have to be developed for the State of Michigan. Evaluation of the state's needs and possible procedures for developing this system are now underway in cooperation with the State Planning Division.

6.4.3. SOIL CLASSIFICATION SYSTEM

Soils information is vital to a comprehensive natural resource inventory and land management program, since soils are an important controlling factor in both vegetation distribution and land use. Soil classification systems have already been developed by the National Cooperative Soils Program and standardized nationally.

For the M-14 highway impact study, certain soil parameters were used to indicate highway impact on the environment. To show these parameters, as well as the feasibility of highway construction, several soil types were grouped as follows:

(1) Natural Drainage
   (a) organic
   (b) alluvial
   (c) poorly drained
   (d) somewhat poorly drained
   (e) well drained

(2) Soil Texture
   (a) fine
   (b) coarse
   (c) alluvial
   (d) organic

(3) Soil Slope
   (a) 0-6%
   (b) 6-12%
   (c) 12-18%
   (d) 18-40%
   (e) gravel or borrow pit

The groupings were specifically selected for highway impact assessment. They are easily mapped and quickly indicate potential problem areas in highway construction or environmental impact. This system is subject to the same problems of universal adequacy as the others. The distribution of soils in an area is a major factor in grouping soil types. For example, if only a small amount of a soil is present it is often combined or lost in another group. This grouping system appears to have merit, but further studies will be necessary to determine whether any grouping standardization is necessary.

6.5. AGENCY CONSIDERATION

State agencies have been kept closely informed of this classification system work. Of these agencies, the Michigan Department of State Highways has incorporated the four-level vegetation classification into their own work on impact analysis. The State Planning Division has likewise been very receptive to the classification systems. The Department of Natural Resources has had only informal opportunity to evaluate this work until further review of the Pointe Mouillee study has been completed. We are confident that other state agencies will be brought into the research at a later date, and that they will utilize the various systems being developed.

7
CONCLUSIONS

7.1. APPLICABILITY OF VARIOUS SENSORS

Aerial photography, as the most familiar form of remote sensing, has long been in use by many agencies with varying degrees of emphasis. Further applications of remote sensing can come from the more frequent and detailed use of available aerial photography, but much additional exploitation of remote sensing technology is possible. The usefulness of conventional aerial photography would be enhanced by more consistent schedules and procedures for collecting, storing and analyzing the data, so that a comprehensive and consistent data base is available. Remote sensing data acquisition programs conducted for multi-county regions or the entire state should be coordinated to provide data consistent with respect to time of acquisition, scale, and film/filter combination.

The high-altitude photography acquired by the RB-57 has proved to be very useful for many purposes, and has been given wide distribution both in connection with this project and as a service to many users studying land resource problems in Michigan. This photography is useful because of its synoptic coverage of large land areas and its use of both natural color and color IR film. The RB-57 photography at contact scales of approximately 1:60,000 and 1:120,000 offers enough resolution for many types of studies involving inventory of vegetation and mapping of land use. For other purposes involving detailed resource analysis, larger scale photography is required.

The airborne multispectral scanner has a capability for quantitative measurements of the spectral and thermal characteristics of the scene. This capability makes it adaptable to such functions as identifying and mapping vegetation species and soils, detecting plant disease, measuring water temperatures, and mapping pollutants in water. Certain of these functions cannot be performed with conventional aerial photography. In those cases where either sensor can provide a given type of information, the selection of the appropriate sensor will depend on the comparative costs and performance characteristics of the two methods. In making these comparisons, the total cost of the final interpreted data must be compared.

The scanner is currently most suitable for conducting intensive studies of limited areas. As this role is expanded with advanced methods of processing, the time and cost of processing scanner data and the need for ground truth collection will be reduced, allowing the economical coverage of greater land areas [4]. As mentioned previously, the ready availability of scanner imagery is an important prerequisite for increased use of this type of sensor.

No studies have been conducted under this project with ERTS-1 imagery, but its applicability to regional studies has been considered. Under a related project, ERTS-1 imagery is being used to prepare a generalized land use and land cover map of Michigan. Other projects are being conducted over Michigan test sites to investigate the feasibility of employing ERTS-1 imagery to perform such functions as soil and vegetation mapping, crop acreage measurement, land use mapping and change detection, and water pollution monitoring. It appears that the imagery will be useful for preparing general land use and natural resource inventories requiring a minimum of supplementary information. In addition, it might be used for monitoring land use change and concentrating field checking efforts on those areas where change is occurring. If this application proves feasible, ERTS-1 data could provide an economical means of keeping land use and natural resource inventory records up to date.

7.2. PROGRAM RESULTS

The first phase of the program has resulted in substantial accomplishments. Through extensive field contacts and discussions recent developments in NASA earth resource survey technology have been brought to the attention of a number of government agencies, inducing them to consider this technology's broad applicability to both immediate and long-range problems. Use of remote sensing techniques to provide information on highway impact assessment for the Department of State Highways and on waterfowl habitat management for the Department of Natural Resources has produced needed information on problems of current concern to these agencies. These successes also comprise practical examples that should prove useful in continuing discussions with these and other agencies as we stimulate the further adoption of earth resource survey methods. Our first phase effort also succeeded in developing separate funding and support by the State Planning Division for the preparation of a state land use map of Michigan as a valuable tool in implementing the State's responsibilities for land use regulation and management.

In our continuation of this work, the substantial results of the program's initial phase will be extended by further agency review and analysis of completed tasks as well as through our demonstration of additional uses of earth resource survey technology.

Project experience to date at creating interest in the adoption of earth resource survey technology through extensive consultation and educational discussions with government agency personnel has been encouraging. The cooperative direction of the project in the highway impact assessment study, the waterfowl habitat study, and other tasks has helped to focus this interest on specific results. Follow-up on this work to obtain agency review and evaluation will be an important means of developing further interest and involvement. Future project efforts in transfer of technology should provide agency personnel with the technical background needed for understanding and using earth resource survey technology; thus these personnel will be encouraged to take the initiative in developing future applications and to participate directly in the work.

APPENDIX

United States Department of the Interior

BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48104

IN REPLY REFER TO:

N2223 RS

November 28, 1972

Mr. Irvin Sattinger
Willow Run Laboratory
University of Michigan
P.O. Box 618
Ann Arbor, Michigan 48107

Dear Mr. Sattinger:

In accordance with your telephone conversation with Larry Peterson concerning use of RB-57 imagery supplied to us by the Willow Run Laboratory and NASA, we report the photographs have been used primarily in three major efforts (1) Detroit-Toledo, Lake Erie Shoreline Study, (2) Southeastern Michigan Water Resources Study and, (3) the Wild and Scenic River Study of the Maumee River.

(1) Use during Detroit-Toledo Shoreline Study was limited because of the initial unavailability of the coverage. The photographs were used for visual inspection to determine marsh and wetland areas, vegetative types, land uses, and changes in cultural elements since publication of the U.S.G.S. maps. Also of special interest were docks, piers, etc., not mapped along the shoreline.

As a result of our study and interest in this area and the discovery of many other activities which will affect those shoreline areas, low level flights were made of the Pointe Mouillee State Game Area. A great deal of baseline data has been collected. This provides information for present managers of the area and will provide information for the decision making process on proposed projects. This data will also help compare the effects certain projects might have on marsh areas such as Pointe Mouillee. It would have been very helpful to have similar coverage of this shoreline area during or immediately after the recent flooding along the western shore of Lake Erie.

(2) Southeastern Water Resources Study. During the spring of 1972, we utilized the RB-57 photos to select and help evaluate potential recreation resources in seven southeastern Michigan counties. Resource characteristics commonly identified on the photos include land and water acreage, miles of stream and lake frontage, density of vegetative cover, and threat of adverse land-use changes.

The values of the RB-57 photos was not truly appreciated until we were forced to use black-and-white aerial photos for three other southeastern Michigan counties. In every respect, the RB-57 photos were superior. The color contrasts and clarity of the RB-57 photos made site selection, delineation, and evaluation a relatively easy task compared with the difficulties and uncertainities we experienced when using the black-and-white photos.

With the aid of the RB-57 photos, 401 sites encompassing almost 300,000 acres of land were inventoried in the seven counties.

(3) Maumee Wild and Scenic River Study. Only three frames were available as the aircraft was turning around at the south end of the flight strips designed to cover southeastern Michigan. These photos were supplied by BOR to the U.S. Forest Service. The Forest Service is a member of the inter-agency study team assigned to complete portions of the report on land use. We have received a letter from them indicating that the RB-57 photography had been very useful in their land use mapping and inquired if we could obtain additional coverage over the Maumee that they could use.

In addition to the three major projects, the imagery has been used for office inspection of various project sites, including dredge disposal sites, potential park areas, highways, surface mine restoration sites, and scenic river studies. All uses except those at Pointe Mouillee have been based on visual interpretations of the imagery by the regional office staff of the Lake Central Region.

We have enjoyed our association with the staff of the Willow Run Laboratory and their individual willingness to assist us upon our request.

Sincerely yours,

John D. Cherry
Regional Director

REFERENCES

1. Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment, Environmental Research Institute of Michigan, Ann Arbor, and Michigan State University, East Lansing, Report No. 190800-1-T, Ann Arbor, December, 1972.
2. Governor's Special Commission on Land Use Report, Lansing, December 14, 1971.
3. Hardy, E. E., R. L. Shelton, D. J. Belcher, and J. T. Roach, New York State Land Use and Natural Resources Inventory, Vol. II, Center for Aerial Photographic Studies, Cornell University, Ithaca, 1971.
4. Marshall, R. E. and F. J. Kriegler, An Operational Multispectral Survey System, Proceedings of Seventh Symposium on Remote Sensing of Environment, Report No. 10259-1-X, Willow Run Laboratories of the Institute of Science and Technology, The University of Michigan, Ann Arbor, May 1971.

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